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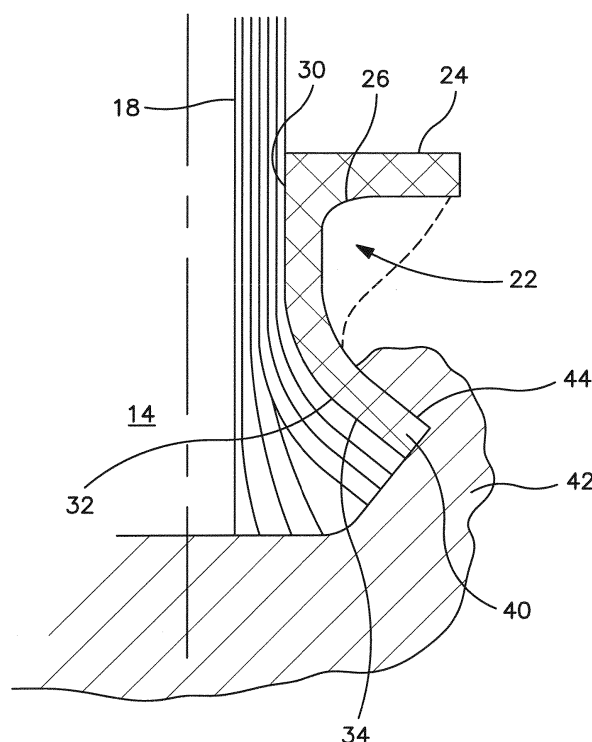
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(54) **CMC BLADE WITH INTEGRAL 3D WOVEN PLATFORM**

(57) A component (10) for use in a gas turbine engine includes an airfoil/root assembly (12, 14); a platform assembly structure (24) having an opening (30) which is bonded to the airfoil/root assembly.



**FIG. 2**

## Description

### BACKGROUND

[0001] The present invention relates to a component, such as a blade, having an integral platform for use in a gas turbine engine and a method for forming same.

[0002] Turbine blades typically require integral platforms, attached to the root region, to form the inner flow-path, and to protect the rim of the disk from hot gas ingestion. The typical cantilevered platform often has to support Blade-to-blade dampers. The combined load of the overhung platform and damper results in large bending stresses at the point where the platform meets the blade root region.

[0003] Ceramic Matrix Composites (CMC) are desired for turbine blades due to their high temperature capability. CMC blades made from layers of cloth or unidirectional tape offer good strength in the primary radial load path. Attaching a platform onto a laminated blade is difficult, and made especially challenging due to the low interlaminar strengths of CMC's. The bending of the platform causes high internal interlaminar stresses, and is a limiter on how long the platforms can function.

### SUMMARY

[0004] In accordance with the instant disclosure, there is provided a method of forming a component for use in a gas turbine engine broadly comprising the steps of: forming an airfoil/root assembly; creating a platform assembly structure having an opening; inserting said airfoil/root assembly into said opening; and bonding said platform assembly structure to said airfoil/root assembly to form said component.

[0005] Further, in accordance with the instant disclosure, there is provided a component for use in a gas turbine engine which broadly comprises an airfoil and a root portion formed from a ceramic matrix composite and a three dimensional platform assembly bonded to said airfoil and root portion. The purpose is to create a platform region, with the inherent complexities, which is independent of the airfoil root structure, thus isolating the large radial pull of the airfoil from the platform assembly. Additionally the extension of the platform region into the lower root portion of the blade assembly simplifies the support of the platform by using the airfoil root to clamp the platform assembly to the disk attachment.

[0006] Turbine blades experience large radial pull loads due to centripetal acceleration. The simplest blades consist of an airfoil connected directly to a root with no integral platform. This simplifies the design of a ceramic matrix composite blade. In ceramic matrix composite the direction of the fibers control the strength of the ceramic matrix composite. For blades in particular, a strong biasing of the fibers in the radial direction imparts high strength with minimal material. The imposed loads on a blade of this type are dominated by the radial pull

and for the airfoil region this creates a large radial tension stress. Bending stress in the airfoil is typically much less. The only region of the blade with large bending stresses is in the root region where it flares outward to form the attachment feature. In this region the ILT (Interlaminar Tensile strength, which is the layer to layer bond tensile strength) of the ceramic matrix composite material is more limiting than the tensile strength. Thus minimizing ILT bending stresses through simplification, and/or reducing the mechanisms that create bending stresses and/or increasing the ILT strength are desired.

[0007] Adding a platform to the existing airfoil/root assembly is challenging as the centrifugal loads created by the cantilevered platform, extending outward from the airfoil, create large bending stresses in the base of the platform where it connects with the airfoil. If the ceramic matrix composite platform was integrally woven into the airfoil region, then the fibers at the airfoil to platform intersection would be exposed to both the large radial load of the airfoil and the local bending stresses of the cantilevered platform. Since ITL strength is much lower than the tensile strength, the design would be limited by the local bending stresses in the platform, and not the airfoil region, resulting in lower capability.

[0008] Separating the blade into an airfoil/root assembly and a platform assembly allows the ceramic matrix composite structure to be optimized for the loads imposed on those assemblies. For the airfoil/root assembly this means a structure with minimal bending loads and a relatively straight load path between the airfoil and the root region. For the platform assembly a ceramic matrix composite structure with improved ITL capability and the ability to create a platform assembly with complex features is desired. Additionally, if the platform assembly was extended to cover the attachment region of the airfoil/root assembly, the complex bending stresses in the root portion of the airfoil/root assembly could be distributed over a larger region of the root, and lower the magnitude of the ILT stresses in the root, thus increasing the capability of that region.

[0009] ILT strength is the strength of the bond between the layers of a ceramic matrix composite. For typical ceramic matrix composites the fiber strength is higher than the matrix strength. Thus for typical assemblies, created by stacking layers, the weaker matrix is the limiting portion, and sets the design limit to the ILT stress of the assembly. In three-dimensional woven forms, additional fibers bridge the layers, such that they increase the ILT capability. A platform assembly made from three-dimensional ceramic matrix composite would have higher ILT capability. Additionally, programmable weaving looms can create complex 3-D woven shapes that can accommodate thickness and dimensional changes through an automated process much faster than by traditional layer by layer assembly techniques. Thus it is desirable to make a ceramic matrix composite platform assembly from a 3-D woven preform for its increased ILT performance with increased complexity.

**[0010]** Bonding an airfoil/root assembly, with optimized ceramic matrix composite construction to a platform assembly with a three-dimensional ceramic matrix composite construction would create a blade assembly with the required complexity of an integral platform and the improved structural performance of due to the combined construction. Additionally the presence of the platform assembly, encasing the airfoil root region, further improves the ILT performance of the airfoil/root assembly by distributing the attachment loads imposed by the turbine disk.

**[0011]** Other details of the ceramic matrix composite blade with integral platform using a complex weave perform are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

**[0012]** According to an aspect of the present invention, there is provided a method of forming a component for use in a gas turbine engine comprising the steps of: forming an airfoil/root assembly; creating a platform assembly structure having an opening; inserting said airfoil/root assembly into said opening; and bonding said platform assembly structure to said airfoil/root assembly to form said component.

**[0013]** In an embodiment of the above, said airfoil/root assembly forming step comprises creating said airfoil/root assembly from at least one of a uni-directional tape layers and/or fabric layers.

**[0014]** In an embodiment of any of the above, said platform assembly creating step comprises forming said platform assembly from a three dimensional woven material.

**[0015]** In an embodiment of any of the above, said platform assembly creating step comprising forming a portion of the platform assembly so that said portion extends radially inward and covers a root region of said airfoil/root assembly.

**[0016]** In an embodiment of any of the above, said platform assembly creating step comprises creating said platform assembly structure so that contact between said component and a disk occurs on an exterior surface of a root section of said platform assembly structure.

**[0017]** In an embodiment of any of the above, said bonding step comprises introducing a matrix material onto said platform assembly and said airfoil root assembly and heating the assemblies to bond said platform assembly structure to said airfoil/root assembly and to densify the matrix material.

**[0018]** In an embodiment of any of the above, the method further comprises grinding off any protruding portion of said component.

**[0019]** In an embodiment of any of the above, the bonding step is carried out by introducing a bonding agent, which after bonding creates an interfacial layer between the airfoil/root assembly and the platform assembly.

**[0020]** In an embodiment of any of the above, the bonding step comprises depositing silicon in a layer on at least one of the blade/attachment assembly and the platform assembly, and then dispersing the silicon into the result-

ing assembly when heated and constrained, thereby forming a continuous bond between the airfoil/attachment assembly and the platform assembly.

**[0021]** According to another aspect of the present invention, there is provided a component for use in a gas turbine engine comprising an airfoil and a root portion formed from a ceramic matrix composite and a platform assembly bonded to said airfoil and root portion.

**[0022]** In an embodiment of any of the above, said airfoil and root portion is formed from a plurality of layers of a tape material and/or a plurality of layers of fabric material.

**[0023]** In an embodiment of any of the above, said platform assembly is formed from a three dimensional woven material.

**[0024]** In an embodiment of any of the above, said platform assembly overlays the root portion so that contact between the component and a disk occurs on an exterior surface of the platform assembly.

**[0025]** In an embodiment of any of the above, said component is a blade, for example, a turbine blade.

**[0026]** In an embodiment of any of the above, said platform assembly includes at least one integral buttress.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0027]

Fig. 1 is a schematic representation of a component which can be used in a gas turbine engine;

Fig. 2 is a sectional view of the blade of Fig. 1; and

Fig. 3 is a flow chart showing the assembly method for forming the blade of Fig. 1.

## DETAILED DESCRIPTION

**[0028]** Referring now to the drawings, there is shown a ceramic matrix composite blade 10 for use in a gas turbine engine (not shown). The blade 10 may be a turbine blade used in the hot section of the engine.

**[0029]** The blade 10 has an airfoil portion 12 and a root portion 14. The airfoil portion 12 and the root portion 14 may be an integral structure formed from a plurality of plies 18 of a ceramic matrix composite material as shown in Fig. 2.

**[0030]** As can be seen from Figure 1, the blade 10 also has a platform 20 and one or more optional buttresses 22 formed from a platform assembly structure 24. The platform assembly structure 24 is formed from a ceramic matrix composite material. The platform assembly 24 process begins with a fibrous pre-form which is in turn infiltrated with ceramic matrix to form a rigid ceramic matrix composite. The fibrous pre-form consists of a combination of three dimensional woven structures and/or portions made from chopped fibers and/or two dimensional woven cloth 26. Two dimensional woven cloth typ-

ically has fiber/tow bundles interwoven such that a large flat sheet is created with a thickness of the sheet being approximately twice the thickness of the fiber/tow bundles. Three-dimensional woven preforms consists of fiber/tow bundles that are woven in such a manner as to have additional fiber/tow bundles such that the thickness can be increased, and complex shapes created where local thick sections can be added and still retain connectivity to the thin sections with continuous fiber/tow connectivity. As will be discussed hereinafter, the platform assembly structure 24 is bonded to the airfoil portion 12 and root assembly 14 so as to form an integral structure.

**[0031]** Referring now to Fig. 3, the method of forming the blade 10 includes the step 100 of forming the airfoil/root assembly by laying up plies 18 of a ceramic matrix composite material in a mold and infiltrating the plies with a matrix material. The plies 18 may be formed from a uni-directional tape and/or a fabric or woven material such that a strong primary structure is created that can transmit the radial pull of the blade airfoil 12 into the root attachment region 14. A fabric may be made from fibers called tows. Individual tows are woven together to create the fabric. Unidirectional-Tape can be made from a collection of individual fibers or a collection of tows, bonded together to form a continuous sheet of uniform thickness. The Unidirectional tape can be cut, like fabric and stacked together with plies. After the plies 18 have been laid up, they may be joined together to form the airfoil/root assembly using low temperature polymerization, high temperature polymerization and/or pyrolysis techniques, or bonding with a Silicon interfacial layer.

**[0032]** As shown in step 102, the platform assembly structure 24 is formed separately from the airfoil/root assembly. The platform assembly structure 24 may be formed from a ceramic matrix composite. For example, the structure 24 may be formed using a plurality of three dimensional or chopped fibers which have been infiltrated by a matrix material. Here again, bonding may be accomplished using low temperature polymerization, high temperature polymerization, and/or pyrolysis, or bonding with a Silicon interfacial layer. The structure 24 may be formed in a mold. Further, the structure 24 is formed to have a central opening 30 which extends from the top to the bottom of the structure 24. In other words, the structure 24 has a hollow core. The structure 24 may be fabricated with one or more chord-wise spaced apart buttresses 22. If desired, the buttresses 22 may be omitted.

**[0033]** The fibers used to form the platform assembly structure 24 may include fibers such as silicon carbide, aluminum oxide, silicone nitride, carbon, and combinations thereof.

**[0034]** The matrix used to form the platform assembly structure and/or the airfoil/root assembly may include magnesium aluminum silicate, magnesium barium aluminum silicate, lithium aluminum silicate, barium strontium aluminum silicate, bariums aluminum silicate, silicon carbide, silicon nitride, aluminum oxide, silicon aluminum

oxynitride, aluminum nitride, zirconium oxide, zirconium nitride, and/or hafnium oxide.

**[0035]** In step 104, the airfoil/root assembly is inserted into the opening 30 in the structure 24 so that the outer edge 32 of the root portion is abutted by an inner edge 34 of the structure 24.

**[0036]** In step 106, the platform assembly structure 24 is bonded to the airfoil/root assembly to form the blade 10. The bonding step may be carried out by introducing the matrix material and heating to densify the ceramic matrix composite material and bond the airfoil/root assembly to the platform assembly. The platform assembly 24 may be formed so that a portion of the platform assembly 24 may extend radially inward and cover a root region of the airfoil root assembly. Alternatively the bonding step may be carried out by introducing a bonding agent such as silicon, which after bonding creates a interfacial layer between the airfoil/root assembly and the platform assembly. Silicon, deposited in a layer on the blade/attachment assembly and/or the platform assembly, would then disperse into the resulting assembly when heated and constrained appropriately, forming a continuous bond between the airfoil/attachment assembly and the platform assembly.

**[0037]** In step 108, any protruding portion, such as fibers, may be ground off.

**[0038]** As shown in Fig. 2, the platform root section 40 is integrated onto the blade root section 14 such that the contact between the final blade 10 and a disk 42 occurs on the exterior surface 44 created by the three dimensional woven platform root section.

**[0039]** While the present disclosure has been described in the context of forming a turbine blade, the method could also apply to the manufacture of other components for use in a gas turbine engine.

**[0040]** There has been described herein a ceramic matrix composite blade with integral platform using complex weave perform. While the ceramic matrix composite blade has been described in the context of specific embodiments thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications and variations which fall within the broad scope of the appended claims.

## Claims

1. A component (10) for use in a gas turbine engine comprising an airfoil (12) and a root portion (14) formed from a ceramic matrix composite and a platform assembly (24) bonded to said airfoil (12) and root portion (14).
2. The component of claim 1, wherein said airfoil (12) and root portion (14) is formed from a plurality of layers of a tape material.

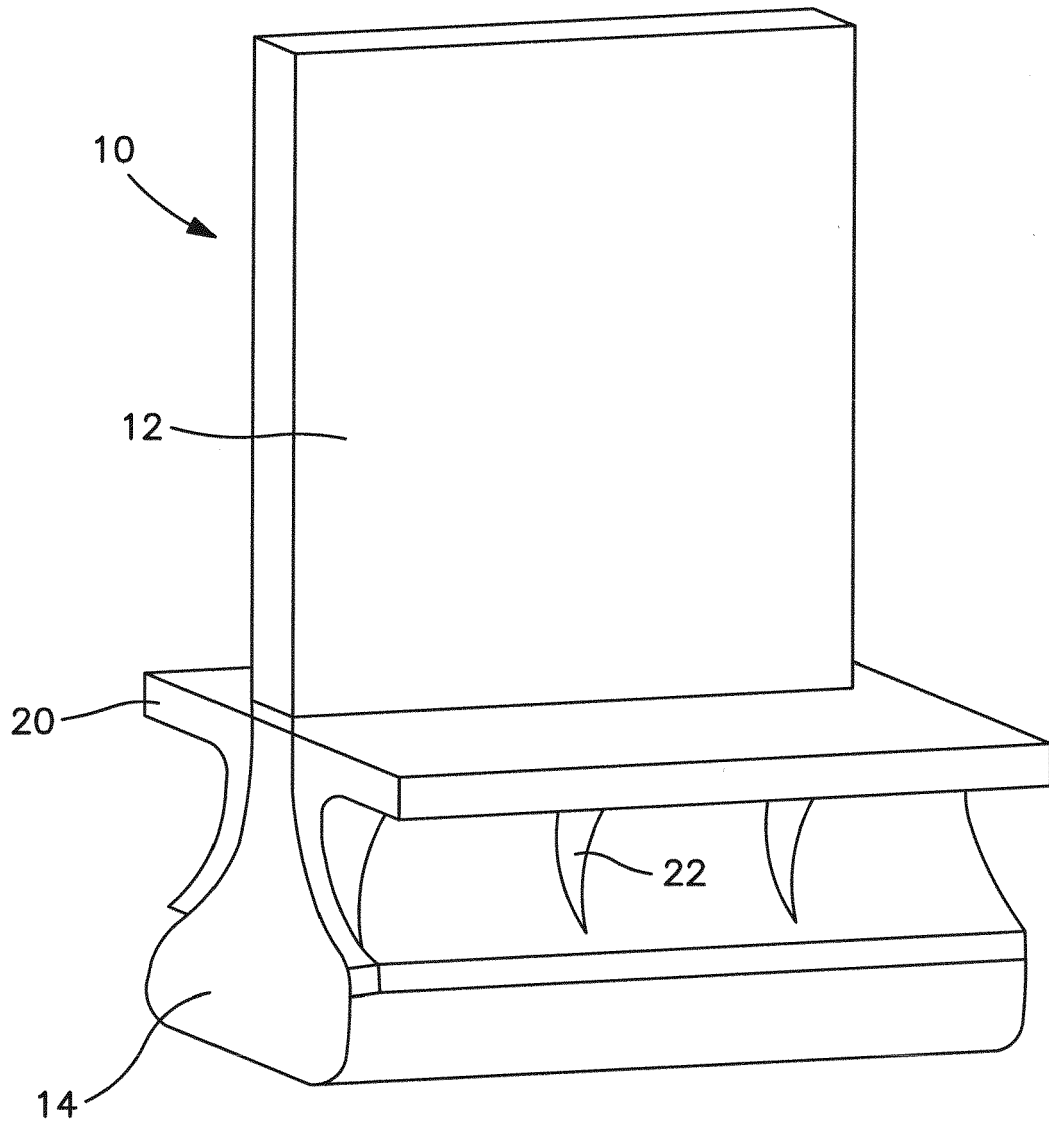
3. The component of claim 2, wherein the tape material is a uni-directional tape.
4. The component of any preceding claim, wherein said airfoil (12) and root portion (14) is formed from a plurality of layers of fabric material. 5
5. The component of any preceding claim, wherein said platform assembly (24) is formed from a three dimensional woven material. 10
6. The component of any preceding claim, wherein said platform assembly (24) overlays the root portion (14) so that contact between the component (10) and a disk (42) occurs on an exterior surface (44) of the platform assembly. 15
7. The component of any preceding claim, wherein said component (10) is a blade. 20
8. The component of claim 7, wherein said component is a turbine blade.
9. The component of any preceding claim, wherein said platform assembly (24) includes at least one integral buttress (22). 25
10. The component of claim 9, wherein the platform assembly (24) comprises a plurality of chord-wise spaced apart buttresses (22) . 30
11. The component of any preceding claim, further comprising an interfacial layer between the airfoil (12) and root portion (14) and the platform assembly (24). 35

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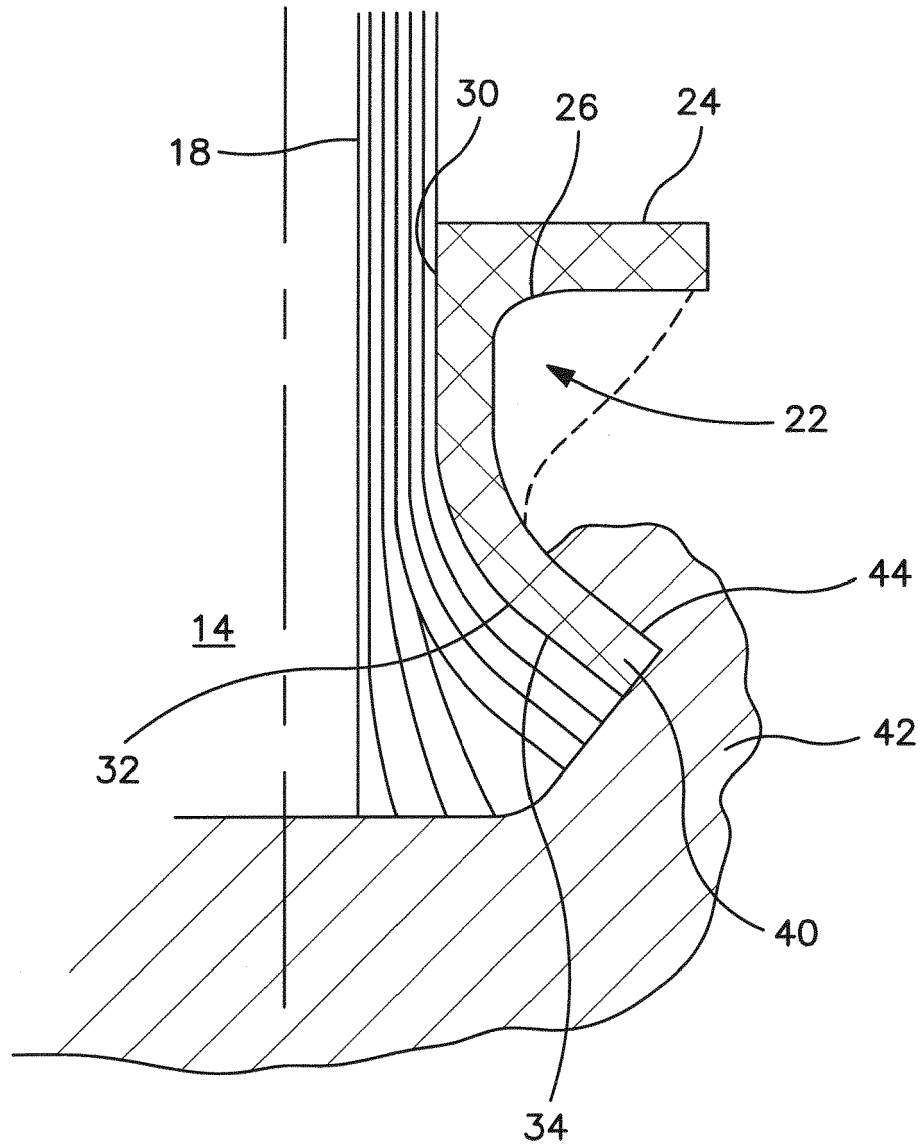
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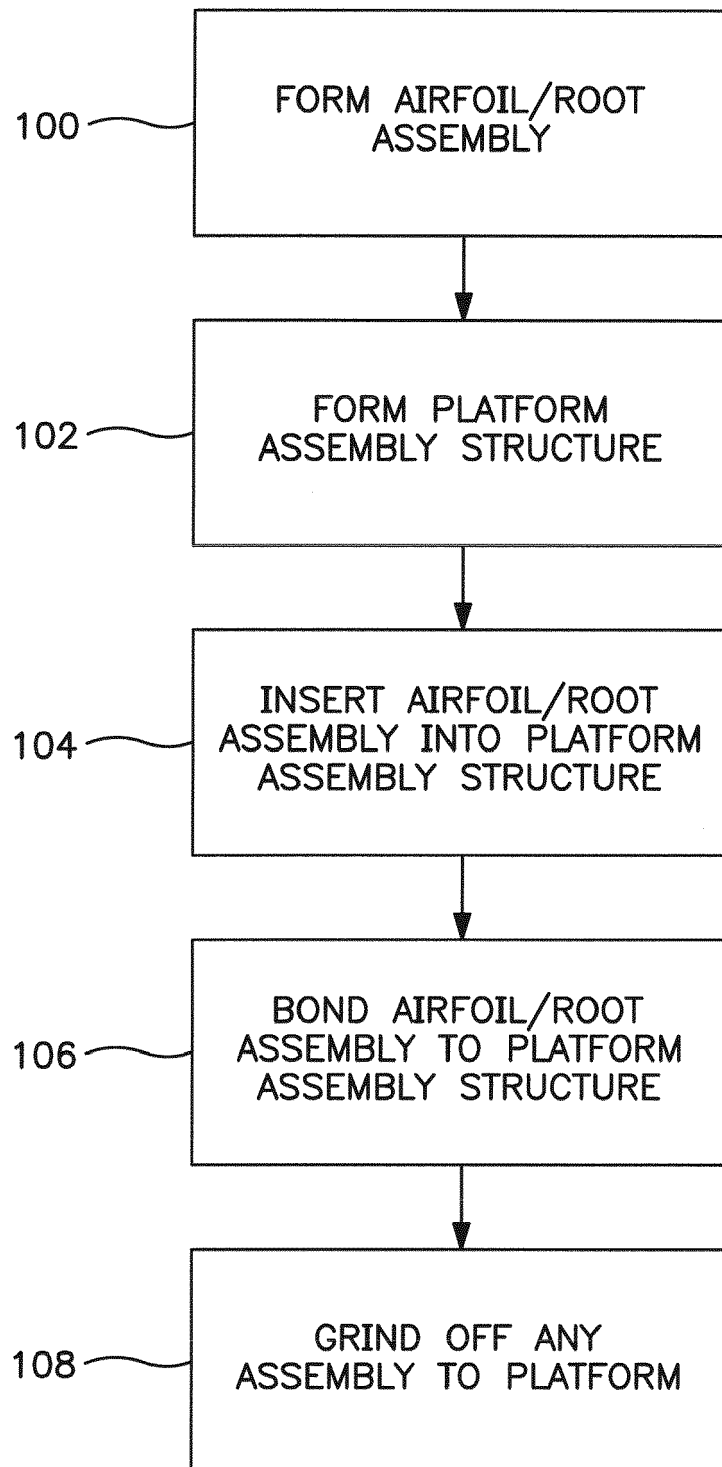
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**FIG. 1**



**FIG. 2**



**FIG. 3**





## EUROPEAN SEARCH REPORT

Application Number  
EP 18 17 4954

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/027098 A1 (NOE MARK E [US] ET AL) 3 February 2011 (2011-02-03)	1-4,6-10	INV. F01D5/14
Y	* figures *	5	F01D5/28
A	* paragraphs [0003], [0031], [0032], [0035] *	11	B23P15/04
	* claims 1, 8, 10, 12 *		
	-----		
Y	FR 2 943 942 A1 (SNECMA [FR]; SNECMA PROPULSION SOLIDE [FR]) 8 October 2010 (2010-10-08)	5	
	* figure 17 *		
	* page 12, line 13 - line 14 *		
	-----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01D C04B B23P
Place of search		Date of completion of the search	Examiner
Munich		26 June 2018	Georgi, Jan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1  
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 17 4954

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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26-06-2018

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Patent document  
cited in search report

Publication  
date

Patent family  
member(s)

Publication  
date

15

US 2011027098 A1 03-02-2011 CA 2747364 A1 08-07-2010  
DE 112009004286 T5 18-10-2012  
GB 2478673 A 14-09-2011  
JP 5537564 B2 02-07-2014  
JP 2012514155 A 21-06-2012  
US 2011027098 A1 03-02-2011  
WO 2010077401 A2 08-07-2010

20

FR 2943942 A1 08-10-2010 BR PI1015161 A2 19-04-2016  
CA 2758077 A1 14-10-2010  
CN 102387908 A 21-03-2012  
EP 2416944 A1 15-02-2012  
FR 2943942 A1 08-10-2010  
JP 5599865 B2 01-10-2014  
JP 2012522937 A 27-09-2012  
RU 2011144510 A 20-05-2013  
US 2012055609 A1 08-03-2012  
WO 2010116066 A1 14-10-2010

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ORM P0459